July 2021

SIEGWERK

NARROW WEB explicit

LED-UV TECHNOLOGY

Challenges and Advantages

LED-UV lighting technology provides longer lifetimes, greater reliability, smaller sizes and they enable system designers maximum design freedom. Traditional UV lighting systems rely on mercury lamps for their light source which are not as reliable, compact, or cost-effective as LEDs. In this paper we want to focus on the challenges and advantages of LED-UV technology and the major breakthroughs of the past years.

FOUR MAIN FACTORS ARE EXPLAINING THE BOOMING OF LED-UV TECHNOLOGY IN GRAPHIC ART.

1

The rising and volatile **cost of energy** has led to the development of more energy-efficient UV curing systems.

2

The increasing awareness of the issues relating to the **environment and safety** has led to the development of curing systems that are **more sustainable** like mercury-free UV lamps, ozone-free systems, UV lamps with higher life time.

Mercury-free systems might become THE argument in the future: *Today the use of mercury lamps is still allowed in Europe due to the exemption of the RoHS2 (Restriction of Hazardous Substance) directive; this exemption might be dropped in the future, especially when mercury-free UV systems will be proven and recognized as a viable alternative to UV mercury lamps.*

3

The market requirement for continuous improvement of **quality** of printed jobs:
The request for easier printing on thin plastic substrates printing (registration) in Narrow Web, the consistency of emitted UV energy in food packaging, the possibility of in-line varnishing and in-line post -printing operations in sheetfed offset are a few examples of the technical advantages obtained with the LED-UV curing systems.

4

Last but not least the **benefits on productivity** realized by switching from mercury to LED-UV curing systems: Instant on/off allows less scrap to be produced at the press start up.

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THE PRINCIPLE OF LED-UV TECHNOLOGY IS NOT NEW, BUT IN RECENT YEARS THREE MAIN BREAKTHROUGHS HAVE HELPED TO SPEED UP THE INTEREST OF UV TECHNOLOGY IN GRAPHIC ART PRINTING:

1

The significant **increase of the UV output** of the lamp (fig.1):

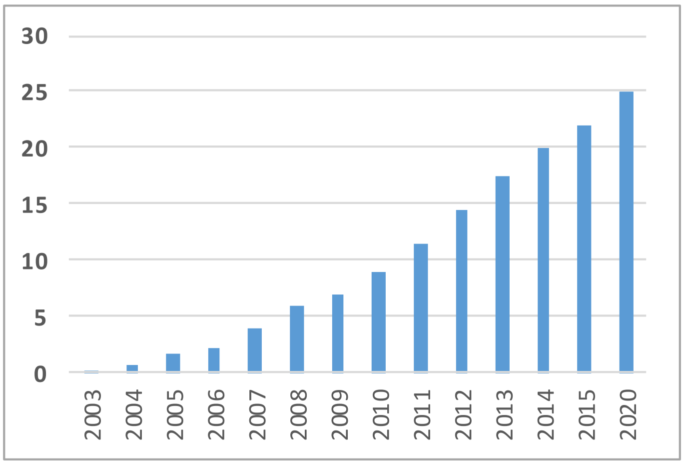


fig. 1: Evolution of LED-UV output (W/cm²)

2

The design and **optimization of the optics** around the LED-UV diodes have greatly increased the efficiency of the LED-UV systems.

3

The **miniaturization** of the LED-UV systems has facilitated the incorporation of UV dryers within the printing press. LED-UV is becoming the preferred option for retrofitting conventional press to UV.

So, after a decade of probing the LED-UV options, developing adapted chemistries, optimizing the processes, expanding the production capacity of LED, the new era is now more focussed on business case justification and integration on presses together with the entry of more suppliers.

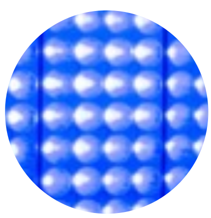
LED TECHNOLOGY:

Principles – Features – Challenges

PRINCIPLES & FEATURES:

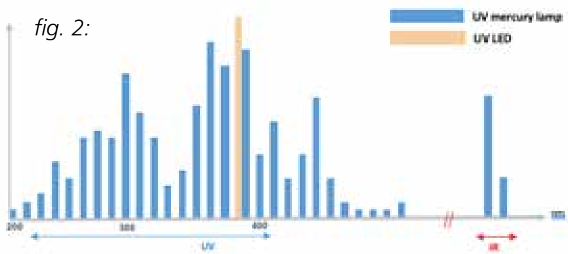
- Light Emitting Diodes (LED) are based on semiconductor material emitting a light spectrum when submitted to an electric current. This principle consumes very little electrical power and generates very little heat (IR).

- Unlike conventional UV mercury (tubes) lamps, UV lamps consist of many LED diodes arranged in several lines (array) and across the width.



- LED emission UV spectrum is monochromatic in contrast to conventional UV lamps based on mercury (fig. 2: Emission spectrum of LED lamp vs standard mercury lamp). The emitted wavelength from an LED depends on the chemical composition of the semiconductor material used.

fig. 2:



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In principle, any wavelength can be obtained by adjusting the semiconductor composition. In practice, the most common wavelengths used in graphic art are 385 nm or 395 nm. There is no emission in UV-B and UV-C: therefore, without emission in short wavelength waves, no ozone is produced.

LED diodes have a very high life time: ~20 000 hours vs ~2000 hours for standard mercury UV lamps (fig. 3)

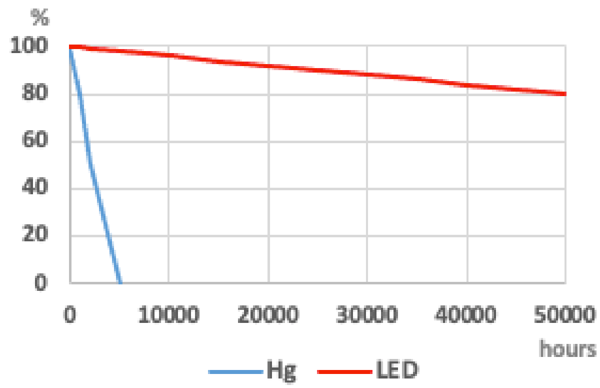

fig. 3: Typical output evolution (%) vs time (h)

LED-UV first successes were obtained in web printing (UV flexo) where the distance between the LED lamps and the substrates is minimized.

Since the irradiance of the UV peak received on the substrate is decreasing proportionally to the square of the distance, LED-UV implementation in sheetfed offset took a longer time. But due to the power increase of LED-UV systems and the significant improvement on the LED optics, the higher distance lamp – substrate is not a stumbling block any more in sheet-fed where the distance between the lamp and the substrate can vary between 7 and 10 cm.

FEATURES:

	Standard UV	LED UV
Lamp type	Mercury	Diodes
Mercury content	Yes	No
Ozone formation	Yes	No
Heat generation	35-45° C	Room T° + 5° C
Typical shelf life	1000-2000 h	> 20 000 h
Installation costs	Standard	Higher *
Energy consumption	Standard	Lower *
Inks costs	Standard	Higher *

**No figures are reported here since many parameters can influence the cost difference*

LED TECHNOLOGY

Advantages

- No mercury filled bulbs
- No infra-red emissions (thermo-sensitive substrates) (e.g. shrinkable sleeves, IML)
- Potential energy saving
- Higher consistency of UV irradiance over time (particularly interesting for food applications)
- High life time (~15 000/20000 h vs 1000-2000 h for standard UV)
- Uniform output of energy across the web or substrate
- Compact (retrofitting easier)
- No exhaust system required (no ozone production)
- No shutter required on the presses
- Full power available immediately after switching on (immediately operational after ignition).
- Higher productivity of white (UV screen white)

LED prepared systems:
Some suppliers propose a single power source and cassette system that allows lamps to be switched in a matter of minutes.

This concept aims to facilitate and speed up the lamp change allowing the printer to have a smooth implementation of LED-UV technology.

LED and mercury lamps on same press:
For those converters who are worried about the yellowing effect of varnishes, again having a dual curing capability on the last station where OPV is being applied could be beneficial.

Multi-wave LED-UV systems:
Instead of using a single wavelength (typically 395 nm or 385 nm), the concept consists in using different diodes on the same ramp in order to enlarge the spectra to 2, 3 or more different wavelengths. This broadens the range of usable photoinitiators in order to increase the ink reactivity or optimize the ink properties (surface curing, lower yellowing systems, cost optimization of recipes).

CHALLENGE FOR THE INK FORMULATOR

SELECTION OF THE PHOTOINTIATOR SYSTEMS

The pallet of available photoinitiators for formulating UV inks to be cured under mercury lamps is relatively wide: the absorption spectra of numerous families of photoinitiator matches to the spectra of emission of a mercury UV lamp.

In practice ink formulators of UV inks usually use cocktails of photoinitiator to maximize the probability of absorbing the UV at different wavelengths: since the mercury UV lamp emits different wavelengths the cocktail of photoinitiator will help to take the benefit of the maximum number of emitted wavelengths.

In the case of UV inks dedicated to LED-UV curing, because of the monochromatic emitted wavelength of the LED lamp, the choice of photoinitiator is limited to the one which is absorbing at the single emitted wavelength (e.g. 395nm, 385 nm). This is the reason why standard UV inks and varnish will not cure properly under LED-UV systems: the photoinitiator present in those inks does not absorb the LED wavelength and does not create free radicals which induce the photopolymerization.

Formulating LED-UV inks requires a selection of photoinitiators that are absorbed in the high wavelengths. This restriction reduces drastically the choice of photoinitiators (fig. 4)

UV VARNISHES

UV varnishes have been a challenge for the formulator for a long time since the extra constraint of low/non-yellowing. This challenge has been overcome in narrow web application both in non-low migration and low migration systems.

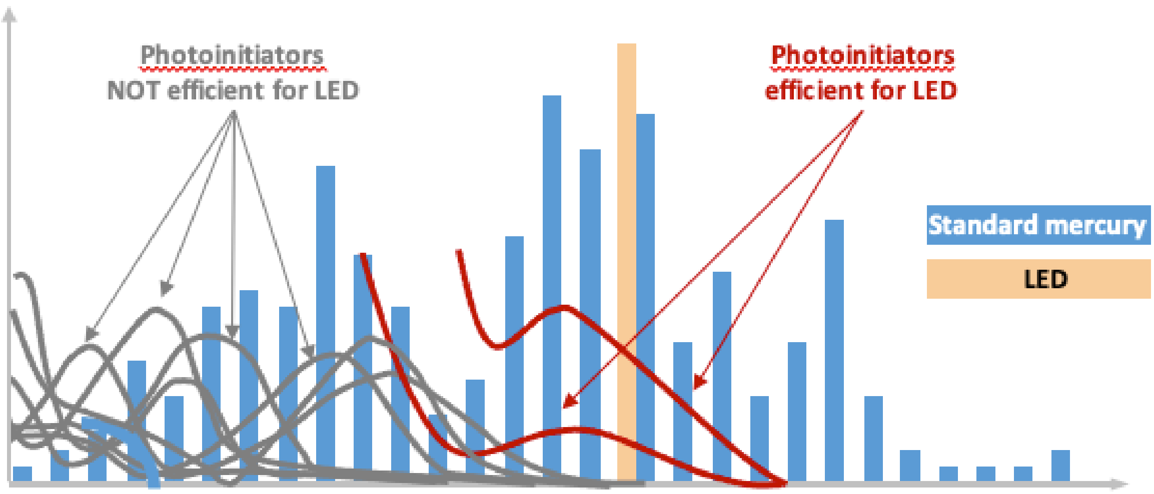

fig.4: Emission spectra of LED & Mercury UV lamps & absorption of different families of photoinitiators

APPLICATION

NARROW WEB APPLICATIONS

Two major reasons explain the quick development of LED in Narrow Web applications:

- The web printing allows a small distance between the LED-UV curing systems and the substrates: this allows the printed inks to receive a maximum UV dose and provides excellent curing
- The easy use thermo-sensitive thin plastic substrate (e.g. for shrink sleeves, or IML applications) because of the absence of emitted IR)

LED-UV FLEXO

LED-UV flexo process is particularly adapted for shrinkable sleeves printing, because of the high temperature sensitivity of thin printed substrates (PET, PVC, OPS): distortion and registration issues are drastically reduced in comparison with conventional UV.

Moreover, the fact that the emitted UV energy is constant in the time, offers reliable and safer curing conditions versus the standard UV mercury lamp. This is of high interest for printing labels or sleeves for food packaging where a risk of migration by set-off or diffusion exists: the consistency of emitted UV energy is an advantage for the GMP.

Low migration UV flexo inks (SICURA Nutriflex LEDTec) can be printed at the same printing speed as "standard" low migration UV flexo inks (e.g. above 100 m/min)

LED-UV Screen

The high efficiency of LED curing for screen opaque white is also an extra reason for the development of LED-UV in Narrow Web. Excellent curing speeds are obtained with the UVA wavelength specially adapted to the through cure of UV opaque white.

COMMERCIAL SHEETFED PRINTING APPLICATIONS

In Sheetfed printing, the greater distance between the LED-UV curing systems and the substrate (up to 10 cm) has been a stumbling block for several years; this has been solved now due to the significant increase of UV power (20W/cm²) and the improvement made on the LED optics. It is currently possible to print with perfecting a 4-color process job at high speeds (up to 20.000 sheets/h) wet on wet with only one LED-UV system.
On top of the great benefits offered by the LED technology (mentioned above), extra specific advantages explain the booming of LED in Sheetfed printing of commercial applications (flyers, brochures, reports, cards, book covers, posters, direct mail):







Quality:
- Higher contrast of image versus conventional offset
- Differentiation possibility inline UV varnish (full or spot varnish with a variety of drip-off effects
- Brighter colors
- Higher mechanical resistances vs conventional offset (no set-off)
- Ink coverage can be increased (up to 350% coverage) offering more possibility vs conventional offset in photogravure)
- Non-absorbent substrates possible with UV vs conventional offset

Productivity / Cost in use:
- Shorter turnaround versus conventional offset printing (immediate post-printing operations: die cutting, folding…)
- Less stock space needed (no waiting time) and better service (faster delivery)

Environmentally friendly:
- Lower energy consumption
- No powder (cleaner environment, smoother surface, no pollution of blankets, time saving)
- Less space needed for retrofitting (no need of extraction of ozone)

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